Chapter 9

Ecological Management, Research, and Monitoring

9.1 Introduction

A major conclusion of this plan is that increased management is essential if the biodiversity of the region is to be preserved. To balance the losses being caused by disturbance of natural processes, ecological restoration and management of this region's natural communities must increase substantially. Years of experience and research have demonstrated that certain basic management activities are necessary and effective for the health of natural communities and the conservation of biodiversity of the region. While continuing research is important to improve management techniques, ongoing management is essential for all of our natural communities. Applying adaptive management in a context of monitoring and research is the best way to improve on existing techniques while reducing and reversing the ongoing rate of loss.

9.2 Techniques and guidelines for ecological restoration and management

9.2.1 Purpose of the guidelines

To facilitate increased management in the region, the Chicago Wilderness Land Management Team has begun the task of developing Ecological Restoration and Management Guidelines. These guidelines will function at two levels. First, they will provide general information about why, how, when, and where certain techniques are used. Second, the guidelines will provide more detailed information that will summarize the state of knowledge about various techniques to aid land managers in planning, training, and working with other land-management agencies and volunteers.

The objectives of the guidelines are:

- To endorse the use of effective restoration and management techniques
- To identify appropriate (safe, efficient, economical, and effective) approaches and solutions for typical management problems
- To identify gaps in knowledge and to develop and prioritize related research questions
- To inform planning efforts with practical information on techniques, costs and benefits, and expected results
- To identify situations that require discussion and information-sharing among land managers
- To foster communication among agencies on issues that require collaborative decisions
- To provide regional support for good land-management decisions
- To provide information to decision-makers with jurisdiction over natural resources

Guidelines cannot identify the specific practices or techniques to be applied at any given site. No single best method or combination of methods can be applied across the region for all situations. Instead, management plans need to be developed for each site using management practices adapted to site conditions and appropriate to the goals for the site. However, guidelines can point out factors and concerns that are helpful in thinking through site plans and use of various practices throughout our region.

Guidelines can help in selecting management techniques to eliminate an ecological stress from a natural community. Some sites with invasive brush can be managed with prescribed fire alone, while others may require hand

clearing, and still others will warrant mechanical clearing. The goal of all of these treatments is to maintain the site using only prescribed fire. But due to different densities of brush and other site conditions, different restoration techniques are needed to get to this stage. In this example, the effectiveness of the restoration technique can be measured in more than one way. First, one can check the reduction of the invasive brush. Second, one can see the intensity and coverage of the prescribed burn. A third, longer-term measure would be the recovery of the natural community.

In most cases, land managers are trying to correct damage done from as many as 200 years of neglect. Restoration is a process that requires time, and some sites may take several years before beginning to show significant signs of progress. It is advisable to fully inform the public of what can be expected and, where possible, to include practices that yield short-term as well as long-term results.

In developing guidelines, the Land Management Team has assigned high priority to specific practices. The following sections explain why these techniques are important, give basic prerequisites for their use, and offer recommendations for enhancing their use across the region.

9.2.2 Prescribed burning

Chapters 3 and 5 have identified fire as a fundamental tool in the restoration and management of natural communities in our region. This tool allows land managers to effectively and economically manage sizable natural areas using a natural process. It is by far the single most important management technique at their disposal.

Planning is the key to successful use of fire as a management tool. Although prescribed burns are essential to long-term health of natural areas, they can have short-term impacts upon some plant and animal (primarily insect) life. For this reason, sites are either burned in portions or on a landscape level that allows natural patchiness to provide refuge. More research needs to be conducted to see how several key species and groups respond to prescribed burns of various intensities, coverages, and frequencies.

Prescribed burns as applied today have several beneficial effects upon degraded natural communities. One of the most important effects is controlling brush by setting small saplings and seedlings back. A second important effect is stressing plants that are not adapted to fire. This allows native species to compete better with the invasive species. A third effect is the recycling of nutrients, which are released from dead vegetation by the fire. Studies have shown that immediately after a fire, plants grow taller, they flower more and longer, and they produce more seed. Fourth, fire exposes the soil and sprouting plants to sunlight and warmth earlier in the year than in unburned areas, allowing earlier growth and more robust plants (Pauly 1997).

A good burn plan includes a clear statement of goals and objectives, a map of burn units, and a prescription that defines the safety parameters: required limits for wind direction and speed, relative humidity, and temperature. The plan also should include optimum timing and conditions, and it should describe the tools and personnel required. Typically, it includes a smoke-management strategy, a notification list, and evidence of all required permits.

Some important references for developing prescribed-burn plans are Collins and Wallace (1990), Henderson and Statz (1995), Hulbert (1988), Wright and Bailey (1982), Packard and Mutel (1997), Ladd (1991), and McClain (1994).

While all land managers for major natural areas in Chicago Wilderness currently use burning in their programs, some actions that would increase the capacity of all managers to use prescribed burning as a management tool. These include the following.

Recommendations

- ✔ Land-management agencies should develop a comprehensive training program for crew members and burn leaders that emphasizes prescribed burning in Midwest ecosystems and burning in metropolitan settings.
- ✔ Land-management agencies should procure sufficient equipment and workforce so that enough natural areas can be burned within the appropriate time periods to achieve the goals of this plan.
- ✔ Chicago Wilderness members should work with the Illinois Nature Preserves Commission to monitor and participate in the development of new legislation that affects prescribed burning in Illinois. Similarly, members should work with state Environmental Protection Agencies as they develop air-quality regulations to facilitate prescribed burns.
- ✔ Land-management agencies, in conjunction with other Chicago Wilderness members, should develop outreach programs to educate local officials, fire chiefs, preserve neighbors, etc., about the use of fire in managing natural ecosystems.
- ✔ Chicago Wilderness members should cooperate to improve knowledge about research questions such as:

- What are the positive and negative effects of prescribed burning on endangered, threatened, and watch species?
- What is the optimum timing and frequency of fire to conserve designated ecological targets?
- What are the effects of various prescribed-burning regimes on native shrubs?
- What are the best uses of fire to control invasive species?

9.2.3 Restoration and management of hydrology

Hydrology includes surface water (ponds and wetlands), groundwater (springs, seeps, and subsurface flow), and riparian systems (streams and rivers). A comprehensive approach to restoring and managing the natural communities of any site should include a thorough review of that site's hydrology, both historic and present. Chapters 3, 5, and 6 describe ways in which the hydrology throughout the region has been altered, typically by the installation of subsurface drain tiles, the channelizing of streams, the construction of dams, dikes, and ditches, the filling of wetlands, and the construction of impervious surfaces.

Modifications to hydrology in the past century and a half were usually attempts to make land more suitable for farming and development, or to convey water off site as quickly and efficiently as possible. Changes in drainage by ditches, tiles, storm sewers, and other means have greatly altered the habitats and ecology of the region. Instead of infiltrating into the soil and then moving as groundwater through the natural communities, most storm water and melt water now run off the surface, changing the quantity and timing of water availability. Hydrologic alteration eliminates some communities and degrades the quality of others.

A review of historical information and a field inspection should determine whether a site has undergone hydrological modification by human actions. A number of information sources can be useful. These include soil analysis, physical evidence of drainage alterations such as field tile or straightened stream channels, aerial photos, topographic maps, and personal contacts with previous owners and local officials. The analysis should also consider the effects of off-site alterations to hydrology.

Before recommending the restoration of hydrology, a land manager must determine if proposed alterations comply with state drainage laws. For example, will they affect surrounding or downstream property owners? This information is essential for obtaining necessary federal, state, and local permits.

Examples of management techniques include removing drain tiles, either in part or in their entirety; filling ditches; removing berms and spoil piles; removing water-level control structures; remeandering streams; controlling invasive species; and reintroducing native species. Monitoring of groundwater levels before and after restoration is an essential component of a successful project.

Some important references in planning hydrological restorations are Brooks et al. (1997), Payne (1992), Mitsch and Gosselink (1993), Galatowitsch and van der Valk (1994), and Hammer (1992).

Recommendations

✔ Chicago Wilderness members and local agencies should create a database of current hydrological data from restoration and mitigation projects and make it available on the Internet.

✔ Chicago Wilderness members and local agencies should standardize the methods for collection of hydrological data, including the use of remote data-sensing equipment.

✔ Chicago Wilderness members and local agencies should provide training to land owners and land managers in techniques for identifying hydrological disturbances, locating and removing agricultural field tiles, and installing groundwater monitoring wells.

✔ Local agencies should identify large, artificially drained wetlands and prioritize them for restoration.

✔ Chicago Wilderness members and local agencies should further develop education and outreach programs on wetland ecosystems, making use of demonstration and restoration projects.

✔ Chicago Wilderness members and local agencies should address key research questions, such as:

- How do offsite factors affect hydrology at a site, and what are the implications for restoring the site's hydrology?
- What are the best methods for restoring hydrology, and when should they be implemented?

9.2.4 Reestablishment of native species

Most restoration management is not focused on individual species. Instead, management seeks to improve diversity and health in general through removal of invasive species, reintroduction of fire, etc. The goal is to improve and enlarge habitat for native plants and animals and to ensure long-term regional viability of native species. In some circumstances, however, the appropriate management technique is the reintroduction of native

species previously lost from a site. Five possible objectives for the reintroduction of native species are:

- To restore natural biodiversity
- To provide expanded habitat for listed or critical species
- To promote conservation awareness
- To develop expanded sources of native plants and seeds and native genetic diversity
- To provide better infiltration of storm water

Species reintroduction can reverse the twin trends of habitat and ecosystem loss and can help sustain rare species. Reintroduction artificially disperses and increases native biota where natural dispersal patterns have been disrupted or fatally compromised. For example, nest predators that prosper in today's fragmented habitat have severely curtailed reproduction of the Blanding's turtle; captive rearing and reintroduction programs are mechanisms to sustain the species. Reintroduction also serves as a tool for recreating the large blocks of native plant communities and community complexes now missing from the Chicago Wilderness region. Seeds and / or plants are reintroduced to degraded natural communities or to former agricultural lands to fill gaps. Large blocks of the native landscape are crucial for the viability of area-sensitive species, to avoid edge effects, and they reduce the chance that a chance event will wipe out an entire population.

Native-species reintroduction in the Chicago region began early in this century with the extirpated white-tailed deer. In the 1960s the region saw its first prairie restorations, most notably the 100-acre project at the Morton Arboretum. Larger-scale projects have now been undertaken, such as the 1000-acre Fermilab prairie restoration, where a phased series of projects on old farmland is creating valuable habitat. In another example of reintroduction, the formerly abundant prairie white fringed orchid is being returned to appropriate sites.

When planning to reintroduce a native species or a mix of species, the site manager must consider several issues about the species' biology and the site, to insure that the reintroduction has a chance of succeeding and will not harm other conservation or restoration efforts. The following items should be considered, especially for sites that contain established high-quality communities or rare species or when working with rare or threatened species:

- taxonomic status of individuals to be reintroduced
- historical information about the loss and fate of species populations from the region and from the reintroduction site, including losses from any previous reintroduction
- the status and ecology of the species or groups of species to be reintroduced
- the effect the reintroduced species will have on the ecosystem and on species currently occupying the required habitat
- the rate of reintroduction, the optimal number of individuals to be reintroduced, and the composition of the reintroduction

The site must be within the historic range of the species being introduced and should offer long-term protection. Previous causes of decline for the species should be eliminated or significantly reduced. Habitat restoration should be at a stage to sustain the reintroduced population.

To retain functioning native communities within Chicago Wilderness, we need seeds and plants of local origin. In some cases, the supply has run short, and some species are not available in the commercial market. Some actions to pursue to develop a larger supply of seed and plants of local ecotypes include the following.

Recommendations

✔ Land management agencies that have not already done so should develop in-house nurseries to produce seeds and plants. A nursery can produce large quantities of seed at low cost and can also produce propagules irrespective of natural environmental conditions.

✔ Expand seed and plant exchanges. Member organizations can trade for seed or plants of the local or regional ecotype that are not available within their own land. This creates a market for the seed and plants that are surplus for one organization but useful to another that year.

✔ Donate or exchange the use of facilities. Local conservation organizations and landowners can make use of each other's facilities or landholdings to build up the number of available propagules. The collaborative efforts create a regional economy of scale and assist individual organizations whose resources are stretched thin.

✔ Conduct propagation research. The task of recovering over 1500 native plant species is a daunting one. Only about 350 of these species have been propagated commercially or for restoration. The personnel and facilities of significant botanical research organizations within Chicago Wilderness provide great potential for research into propagating native plants for restoration and could act as a clearinghouse for such work. Such botanical facilities include the Chicago Botanical Garden and the Morton Arboretum. Staff from these facilities can and also do help in preparing recovery plans for rare species.

✔ Work with home gardeners. Volunteers have provided their backyards as nurseries for several plant species identified for inclusion in restoration seeding. Gardeners receive seed or plants to grow in their backyards. The seed from these plants is collected and used in restoration projects.

Research topics of importance to enhance the success of species reintroduction projects include how underground biota influence reintroduction of flora; autecology and synecology of little-known species; and propagation and dispersal requirements for selected species. Specific research and recovery needs for priority plant species are included in Chapter 7.

References useful for planning plant species re-introductions include Bowles (1990), Falk et al. (1996), Packard and Mutel (1997), and Swink and Wilhelm (1994).

9.2.5 Control of invasive plant species

The invasion by aggressive species is an international conservation issue of the most serious concern, because it threatens native biodiversity in regions and preserves across the globe. Invasive species are those that become established in natural or semi-natural ecosystems or habitat, are an agent of change, and threaten native biological diversity. The international Convention on Biological Diversity recognizes invasive species as one of the major threats to biodiversity and calls upon the governments of the world to take steps to prevent the introduction and manage the impact of invasive species. The Field Museum hosted an international symposium addressing this subject in 1997. Locally the goal is to reverse the trend of degradation caused by invasion and to minimize the negative alteration of natural communities.

Approximately two dozen invasive plant species are currently causing serious and sometimes devastating damage to natural areas in our region, reducing native plant diversity (and thereby associated animal diversity) by successfully competing for space, water, sunlight, and nutrients. Once established, these plants are difficult to eliminate or control. Most of our invasive species are introduced from the Old World, but others are native species that have become similarly aggressive with the disruption of normal ecological processes, such as alteration to natural hydrology or suppression of natural fire. The spread of these species is recognized as a direct threat to natural communities and to some endangered species, and it is arguably the greatest single threat to the integrity of the flora and fauna of the Great Lakes region.

A plan to control invasive species is an important element in any management plan. In dealing with invasive species, two important maxims are that prevention is at least as important as eradication and that identifying and resolving the cause of the invasion is a critical step in control. Some invasive species are of region-wide concern, not only causing impacts where they occur, but also posing a threat to parts of the region not yet invaded. In such cases it is important for Chicago Wilderness to develop a regional component to planning, research, and control. Decisions about specific methods for controlling invasive species depend on several variables including the species involved, the nature of the invasion, surrounding environmental conditions, resources available, and the management objectives for the area. In most cases a combination of control methods works best. Three categories of control are available:

Physical control

Physical controls include prescribed fire, mowing, restoration of hydrological function, cutting, pulling, girdling, and other methods that physically remove or weaken the invasive species, promoting successful competition by natives. Mowing can be effective for the control of some annual and biennial pioneering invaders if native plants are available to provide long-term competition. The timing of mowing is important, both to achieve control and to avoid injury to nesting grassland birds. Hand pulling or removal of seeds can be effective for small areas, but is labor intensive. Girdling is an important tool when working in high-quality areas or for creating habitat for cavity-nesting birds or bats. Sections 9.2.2 and 9.2.3 discuss management with fire and hydrological restoration. Flooding by manipulating water levels can be effective in some wetland situations where some species such as cattails can be drowned.

Biological control

Biological control uses the natural enemies and competitors of a species to control its population. Predators or diseases not currently known in the area are used. These should be host-specific to avoid negative impacts on non-target species. The USDA closely regulates such introductions. Currently biological controls are being implemented for purple loosestrife and Eurasian water milfoil. Early indications look positive. The use of bacterial sprays to combat gypsy moths is of some concern, since the bacteria also destroy some native moths and butterflies. Another form of biological control is the seeding of native plant species that may in time out-compete invasive species under restored natural conditions.

Chemical control

Herbicides are by far the most commonly used pesticide in management of natural areas. They are often used in combination with physical or biological controls. In most cases, they are used on a temporary basis with the objective of establishing a balanced condition where the nat-

ural processes of fire and competition by native plants will be sufficient to exclude the invasive species. Herbicide is commonly used to control brush when it has grown beyond the size controlled by fire and when its shade has limited the availability of fuel.

Before any pesticide can be sold in the United States, it must be registered and approved by the U.S. Environmental Protection Agency. How the pesticide may be used is governed by terms specified in the product label, which has regulatory authority and limits the amounts to be used and the conditions under which application occurs. State governments test and license individuals seeking to apply pesticides commercially or on public land, usually through their departments of agriculture. Land-owning entities may have additional rules about use of pesticides and qualifications of those applying them.

Used according to label requirements, herbicides provide a cost-effective and safe means of controlling invasive vegetation, especially in short-term situations where the problem has arisen because natural processes have been disrupted by human activity. In most such cases, the best long-term solution is to restore the natural processes to the maximum extent possible. For example, buckthorn can be controlled by prescribed burns, but only after the large buckthorns and their roots have been controlled with herbicide.

It is important for each landowner to establish priorities for invasive-species control. Of highest importance are:

- preventing new infestations
- targeting the existing problems that are the fastest growing and fastest spreading
- targeting species that are the most disruptive to natural ecosystems
- monitoring for new threats and stopping them before the new species becomes established

The following species are particularly problematic invasive plants in the Chicago Wilderness region. These species are currently causing biodiversity loss and, if left unchecked, will cause irreparable damage to our native species and communities.

Garlic mustard	*Teasel*
Canada thistle	*Tartarian honeysuckle*
Purple loosestrife	*Reed canary grass*
Black locust	*Crown vetch*
Moneywort	*White and yellow sweet clover*
Giant reed grass	*Glossy buckthorn*
Common buckthorn	*Multiflora rose*
Leafy spurge	*Oriental bittersweet*
Autumn olive	*Narrow-leaved cattail*

Native species can become invasive under some conditions. One example is the invasion of prairies and woodlands by gray dogwood, box elder, elm, ash, etc. in the absence of regular fire. The control of these species should be addressed in management plans.

In addition to these problem plants, several invasive animal species are causing harm to or threatening biodiversity in the region.

Many of the actions to protect terrestrial and aquatic communities from the threat of invasive species are discussed in earlier chapters.

Recommendations

- ✔ Continue to develop and share cost-effective protocols for controlling targeted invasive species.
- ✔ Monitor species locally and regionally to identify and anticipate problems before they reach epidemic proportions.
- ✔ Develop region-wide collaborative efforts to control invasive species on all public land not already managed for biodiversity, including utility and transportation rights-of-way
- ✔ Develop and promote native landscaping recommendations for residential and commercial properties that strongly discourage the use of potentially invasive species in landscaping, working through nurseries and other outlets.

9.2.6 Management of problem wildlife

The fragmentation of ecosystems in the Chicago Wilderness region and the growing populations of some wildlife species (especially deer) present real challenges to the conservation of biodiversity. Each native plant and animal species is valued as a component of ecosystems. Some wildlife species, however, are having quantifiable negative impacts upon plant and animal communities and ecosystems. As discussed in sections 3.3.7 and 5.7.9, many species and natural communities are threatened by overabundant animals. Over abundance can destroy ecological balances, destabilizing relationships within the community and making it vulnerable to invasive species. Such species (native or introduced) are problems that require careful attention. Some animal species cause damage or inconvenience to people, and some are a threat to rare species and healthy natural communities.

In aquatic communities, the zebra mussel, round goby, rusty crawfish, and common carp can drive other species to local extinction. Research on the national or larger regional level is badly needed to find ways to protect high-quality ecosystems from these species. The Canada

goose, though native, has become so abundant (in the absence of natural predators and through creation of artificial habitat) that it pollutes some waterways and conflicts with human uses of its favorite local habitat, mowed lawns. It is also very destructive of efforts to restore wetlands.

In terrestrial communities, some native species have become overabundant due to the loss of large predators (wolves, mountain lions, and human hunters). Thus in many areas, breeding birds are heavily impacted from high numbers of smaller predators such as raccoons, skunks, and opossums.

A severe threat to many songbird species is nest parasitism by the brown-headed cowbird. The cowbird once had only temporary impact, as it followed wandering herds of bison. Today it thrives in mowed areas and is able to invade all parts of most of the region's fragmented forested habitats, permanently thwarting most reproduction by some species.

Thousands of stray and feral cats roam the Chicago area, the suburbs, farmlands, and natural areas. These animals have significant impacts on wildlife populations and can be health risks to other cats, wildlife, and humans. Recent research suggests, for example, that rural cats in Wisconsin are killing an estimated 39 million birds per year (American Bird Conservancy 1998).

One of the most serious threats to woodland and other communities in the region comes from white-tailed deer. The continuing development of open lands removes available deer habitat, concentrating deer in limited remaining open space. These deer consume a great number of plants and, if unchecked, their consumption leads to the loss of native plants and animals, including endangered species. The effects of excessive browsing are many. (See Crawley (1983) for a summary.)

Deer populations can grow rapidly in the absence of natural predators and regular management. A study of radio-collared deer from DuPage and Cook counties from 1994 through 1998 found that adult deer have high annual survival rates (>80%) and few natural predators. Automobiles and trains accounted for more than 60 % of urban deer mortality (Etter 1998). Populations can more than double annually in the absence of predators if left unchecked.

Deer management in the Chicago region currently occurs under approved management plans. A plan for managing deer (or other wildlife) involves:

1. Identifying the problem and measuring the extent of damage caused by the wildlife
2. Evaluating possible solutions and techniques for abating the damage and selecting techniques
3. Educating the public, agency personnel, and decision makers about the problem and the need for the recommended solution
4. Obtaining all necessary local, state, and federal permits
5. Developing a monitoring program to evaluate success and making changes as needed

Important tools in deer-management programs are models that predict the response of a population to management or lack thereof. With the high degree of scrutiny that wildlife-management programs receive, models are essential to the careful choice of a management solution. A project funded by Chicago Wilderness has developed a simple deer management model, based on data from local studies, that helps managers predict trends in a deer population (Etter 1999).

In forest preserves and other public lands in Chicago Wilderness, deer are removed by state-qualified sharpshooters. Work occurs when preserves are closed. Venison is donated to local charities, including the Greater Chicago Food Depository. This is the best available method and is used by agencies nationwide. Contraceptives may one day offer an effective form of population control, but no practical programs have been demonstrated.

Increasing the efforts to limit the damage from deer and invasive animals is of great importance to biodiversity conservation in the region. The following actions would enhance the effectiveness of such programs.

Recommendations

- **Deer**
  - ✔ Until effective alternative methods become available, deer should be harvested regularly to limit numbers to levels that support a balance that sustains a full range of native plants and provides diverse habitat for birds and other animals.
  - ✔ Disseminate any new information on alternative control methods to land managers.
  - ✔ Disseminate models that predict responses of deer populations to management to managers and encourage their widespread use. Continue to improve existing models based on additional field research and the incorporation of stochastic functions and spatial components.
  - ✔ As deer populations are managed and reduced in size, there will be an increased need for more accurate census techniques. Additional research should

be carried out to develop more effective census techniques in general.

- ✔ State and federal agencies should provide support for collecting information from deer harvests that can provide a basis for future decisions about deer management. This information would include collection locations; gender; the number, gender, and age of fetuses; and reproductive information.
- ✔ Public agencies (and private landowners where relevant) should cooperate more closely to manage deer across borders of managed lands.

- **Zebra mussels and the round goby**
  - ✔ Support continued research on limiting the spread of zebra mussels. Promising research pursued by Chicago Wilderness members shows that control of zebra mussels in river systems would be most efficiently focused on particular upriver source sites rather than on the entire river. Illinois Natural History Survey (INHS) found that removing zebra mussels or constructing barriers to prevent down-river dispersal of larvae would have a strong negative effect on down-river populations. Plans are underway to construct a dispersal barrier to the round goby, another invasive species, in the Chicago Ship and Sanitary Canal.
  - ✔ Provide more public outreach and education calling for boat owners to take responsibility for cleaning boats and boating equipment prior to transporting them from one water body to another.
  - ✔ Promote research on methods to control zebra mussels and round goby.

- **Feral cats**
  - ✔ Chicago Wilderness members should lead a public education effort explaining the problems caused by feral cats and advocating that people not feed stray cats, support cat licensing laws, support humane removal of stray cats from neighborhoods and wildlife areas, and keep domestic cats indoors.

9.2.7 Management plans

To guide and coordinate conservation of biodiversity in the Chicago Wilderness region, management plans are needed at several levels. At the broadest, regional scale, this Biodiversity Recovery Plan seeks to describe and gain consensus on existing conditions, goals for recovery, and the major steps needed to reach the goals. At the other end of the geographic scale, each managed site should also have a site plan that describes its current condition, desired conditions, and the steps needed to attain them.

Depending on the preference of the landholder, a site plan can cover a few acres or thousands. For a large site with multiple habitats and ecological communities, a set of plans for smaller areas may be appropriate. Especially for publicly owned lands, plans need to provide a logical basis for conservation and restoration that informs and enrolls support of all stakeholders. Such plans should also reflect other plans, such as those for recovery of endangered species, greenways, stream restoration, and water trails.

Between the regional recovery plan and the site plans there may be multiple levels of plans by landowners such as the counties or states, based on their needs and policies. Plans at all levels must support each other, providing a clear path to recovery.

The content of management plans varies greatly depending on the needs of the organizations involved. In addition to addressing the questions of where we are now, where we are trying to go, and what actions are needed, other important questions are: what natural processes have been disrupted, what human activities are causing problems, and how will progress be monitored?

The Science and Land Management Teams of Chicago Wilderness are continuing to define management techniques, suggested content of site plans, and recommendations for site monitoring. One recommendation can be made now.

Recommendation

- ✔ Chicago Wilderness members should support regional ecological performance standards, monitoring techniques to measure attainment of the performance standards, and evaluation techniques (such as a regional report card) to evaluate land restoration and management.

9.3 Monitoring and adaptive management

9.3.1 Introduction

While land managers use the best available knowledge about communities and species, there is always opportunity and need to improve management techniques and to learn more about ecosystems. Management and monitoring need to be organized so that they help evaluate the effectiveness of current techniques, and management needs research projects that answer questions relevant

to management. Research, monitoring, and inventory are distinct activities, yet they must be linked to make their results immediately useful to conservation practitioners. Management within an experimental framework, making use of results in future management decisions, is referred to as adaptive management. Developing and implementing a regional monitoring program and pursuing a prioritized research agenda will provide significant contributions to conservation of biodiversity.

Central to the adaptive approach proposed here is multiscale ecological monitoring, a process for measuring progress toward goals for conservation and ecologically sensitive development. Chicago Wilderness members are designing a region-wide monitoring program that will detect change in pattern and process at three levels: (1) the landscape, (2) natural and human communities, and (3) species. At every stage of design and implementation, this monitoring program will involve a broad spectrum of stakeholders in the region's ecological health: professional scientists, citizen scientists, volunteers, schools, land managers, local businesses, community-based organizations, and urban planners, among others.

Much ecological monitoring is already underway in the region. Now is the time to unify and strategically add to these efforts, so that their results can keep pace with rapid region-wide change. Critical for this effort will be a monitoring framework that allows integration across space and time, as well as across organizations, and that strengthens and streamlines the participation of diverse contributors. Here we propose a flexible thought process for designing such a framework, to be tested among the complexities of this metropolitan ecosystem.

9.3.2 Adaptive management and conservation design

Conservation design is a process for deriving conservation goals and strategies directly from assessment of biological values and the threats to those values. Although conservation design is site-based, the "site" can scale from a single natural area to an entire region. A region-wide ecological monitoring program is just one outcome of the conservation design process. Others are a program of scientific research and an agenda for ecological inventory. We consider monitoring, research, and inventory distinct but closely related:

- Ecological monitoring is an iterative process for measuring progress toward conservation goals.
- Ecological research is a systematic approach of posing and answering questions to reveal cause-and-effect relationships.
- Ecological inventory is a snapshot of conditions at one time (e.g., species richness, population distribution, pattern of vegetation on the landscape) that establishes a baseline against which to measure change over time.

Conservation design focuses our efforts in monitoring, research, and inventory so that they contribute directly to conservation action. Each of these three activities incorporates human elements into the larger context of regional biodiversity, with the ultimate goal of improving quality of life.

We approach conservation design through a series of questions that allow us to identify biological (including human) values, threats to these values, and adaptive action to protect these values from these threats. The questions include:

- What is the geographic scope of our conservation efforts?
- How does this site work (at scales ranging from individual preserves to the whole region)?
- What do we want to protect or enhance within this site?
- What do we want these targets to look like in x years?
- What could prevent us from achieving this vision for our targets?
- What should we accomplish to offset these threats to specific targets?
- What will we do to reach these goals and objectives?

The work to produce this recovery plan has provided initial answers for several of these questions. Chapters 4 and 6 identify our initial conservation targets to answer the third question. Chapters 4 and 5 offer vision statements to answer the fourth question. Immediate next steps are to complete the conservation design and to begin implementing an integrated program of inventory, monitoring, and research.

One result of this process will be the identification of conservation and development strategies. These become the experimental treatments of adaptive management. Addressing the most severe threats may require a mixture of innovative strategies drawn from science, policy, stewardship, and institution building. Once a strategy is in place, conservation and development actions define the schedule, people, and funds necessary to implement it. Ongoing work will link strategies to goals; ultimately, our aim is to address human and natural communities

simultaneously. Like the rest of the plan, these strategies are evolutionary: we will learn both from our mistakes and from our successes.

9.3.3 The link between management and monitoring

Ecological monitoring is the mechanism regulating the loop between our management goals (including goals for restoration) and our strategies for conservation and development. How can we make that mechanism both concrete and adaptive? In Chicago Wilderness, we are testing an approach to monitoring design that builds on the process of conservation design. As in conservation design, our emphasis is on action.

Our approach to monitoring design is as follows:

Choose indicators

An *indicator* is a variable that measures change toward a goal / objective or in completing a strategy / action. *Outcome indicators* show whether we are reaching our threat-related management goals and objectives; *performance indicators* show whether we actually have implemented the strategies and actions that we devised to accomplish these goals. Although in a few cases we may find a single variable that is sufficient to answer our questions about progress for a particular goal or strategy, usually we will use multiple indicators that draw from several levels of organization and that address some combination of composition, structure, and function. The key is to find the smallest set of indicators that will give us confidence in our conclusions. Chicago Wilderness members are interviewing land managers, planners, and scientists to reveal potential monitoring indicators for the landscape, human and natural communities, and species. Later we will determine the optimal subset of these possible indicators related to our goals and strategies. We will rank these indicators by analyzing threats and will aggregate them across geographic scales. Even if we find some indicators that we can use successfully at all sites in the region, we still will use many site-specific indicators.

We emphasize that indicators are variables, not organisms. We may use the population size of threatened prairie species A, for example, as an indicator of progress toward a goal of reestablishing viability for species A. If we have good evidence that threatened species B or prairie species C shares species A's conservation needs, we may feel confident in using A's population size as a proxy in measuring progress toward our goals and strategies for B and C. Very rarely, if ever, will we find an indicator related to a single taxon that will "speak for" the health of an entire ecosystem. More useful will be suites of indicators, perhaps including composite variables that are indices of quality or integrity.

Set thresholds

A *threshold* is a value of an indicator that, when crossed, sends up a "red flag" calling for a management response. The response might be a policy change in a human community as well as a change in the practice of ecological stewardship of a natural community.) This threshold may be tied to status (e.g., "respond if the population of species A declines to 500 individuals") or to trend (e.g., "respond if the population of species A is declining by 10 individuals per month"). Like establishing a vision for conservation or development targets, deciding on appropriate thresholds involves many uncertainties, and hence discomforts, for the decision-makers. In Chicago Wilderness, we will rely on a combination of targeted research and the extensive experience of land managers to set and refine these thresholds.

Plan options for management responses

Knowing *when* to intervene does not imply that we know *how* to intervene. Red flags may go up quickly, and we must be prepared to act. Given the uncertainties inherent in systems as complex as ecosystems, we are unlikely to be successful in specifying a fixed management response when a particular threshold is crossed. Instead, we must plan a range of options. For the most part, we will direct our responses toward sources of threats, rather than the stresses associated with them. Once again, the wealth of knowledge in Chicago Wilderness institutions and individuals will supply options for management intervention. Research and cycles of monitoring will modify these options as time goes on.

Design sampling protocols

Once we have laid out monitoring indicators, thresholds, and responses, we will focus on sampling design, including intensity of monitoring and methods of data collection. Our methods must be not only scientifically sound but also as simple and cost-effective as possible. In our interviews of land managers, planners, and scientists, we will use current and past monitoring methods as guides for the future. In addition, a workshop will provide intensive training in sampling design, as well as program design, specifically tailored to the needs of the region.

Implement the monitoring program

The monitoring program for Chicago Wilderness is already in progress. Projects range from landscape-level measures of change in vegetation cover to measures of change in the populations of individual species in particular preserves. Through the process of monitoring design described above, we will consolidate, adapt, and

unify this program so that stewards can benefit from the landscape-level results and the region can benefit from the data of individual conservation areas. Participation by the broad range of actors in Chicago Wilderness will be central to success.

9.3.4 The link between research and monitoring

To have confidence in monitoring results, we must have confidence in at least two kinds of linkages: between source of threat and the stress that it creates on a target, and between a conservation or development strategy and the goal that we hope to achieve thereby. Through concentrating research effort on the linkages between threats and the highest-priority targets, and between strategies and the highest-priority goals, we can ensure that investment maximizes conservation impact.

As with monitoring, research at many levels of organization is flourishing throughout Chicago Wilderness. The Recovery Plan outlines overall research needs: the gaps between what we now know and what we need to know to promote the quality of human and natural communities. Our next step will be to link these needs for research more specifically to the questions given in section 9.3.2.

9.3.5 The link between inventory and monitoring

Even in Chicago Wilderness, a landscape with a long history of scientific study, we still lack inventories of some taxa and natural communities, both for particular conservation areas and for the region as a whole. As we design monitoring programs, biological and socioeconomic inventory becomes critical for measuring change. How can we make these assessments cost-effective, as well as connect them tightly to our goals and strategies for conservation and development?

We are experimenting with several nontraditional approaches to ecological inventory. Using satellite imagery, aerial photography, and Geographic Information Systems (GIS), we are conducting *inventories at the landscape level*, such as vegetation maps and quantitative analyses of cover type. As we couple this remote sensing with ground truthing and representative assessment of species and communities within cover types, we increase our confidence in the use of these landscape units as surrogates for units of biodiversity at smaller scales. We also are evaluating the effectiveness of *rapid assessment methods* for taxa that give clues to the current condition of natural lands and waters. We recognize the need for a baseline of *human ecological data*, as well; we are drawing on existing databases of real-estate trends in Chicago-area neighborhoods and are exploring the possibility of incorporating other social and economic information.

9.3.6 Information management for monitoring

Through the design process outlined here, we will work toward a regional framework for conservation science in which monitoring, research, and inventory interlock and support one another. Holding this framework together will be a system of information management that allows us to scale across geography and across levels of organization. Chicago Wilderness has begun to develop an electronic catalogue of geo-referenced data sets held by member institutions. One of our greatest challenges will be to integrate data for human and natural elements across the entire region. One of our greatest strengths is a commitment to participation by a complete cross section of stakeholders in information management. Participatory data management not only strengthens our scientific framework but also fosters the dedication of the region's human communities to conservation and ecologically sensitive development.

9.3.7 Promoting management-related research

The complexity of ecosystems and ecosystem function is greater than we are capable of imagining. This becomes more apparent when we attempt the tasks of rebuilding and restoring natural communities. Having a complete understanding of these systems is not necessary to begin preserving them, but improved knowledge is needed to support long-term preservation and restoration of all species and communities and to improve efficiency. If we begin to work while there are sufficient species and fragments of habitat left, under intelligent management and with restoration of natural processes, the fabric of these natural communities may mend itself. Nonetheless continued research is necessary to better guide restoration.

Traditional science has enumerated and described species and communities. Today, as management of our natural resources becomes more important, scientific research is critical in guiding and in determining the success and direction of these management efforts. To reach our conservation goals, a better understanding is needed of the presettlement landscape conditions and processes, of current landscape condition and processes, of the best techniques to improve ecological health, and of requirements for sustaining biodiversity over the long term. Scientists and land managers in the Chicago Wilderness region should work together to compile a prioritized list

of research needs and to support research projects that will lead to this improved knowledge.

The Chicago Wilderness consortium has already brought together scientists, restorationists, and policy makers to focus attention on important research questions and gaps in information. Now, an atmosphere needs to be fostered that will promote the investigation of these questions. A first step is to build better links between land managers and academia and to promote more research projects within the region.

Existing scientific knowledge about regional natural areas needs to be published and integrated. Integration of this knowledge with programs to develop monitoring protocols, to conduct further inventories, and to address additional research needs will help to ensure preservation of much of the biodiversity of the region.

Recommendations

- ✔ Compile a prioritized list of research needs and support targeted research projects with internal and external grants.
- ✔ Set up a central source of information for students and professors about priority research needs.
- ✔ Promote the Chicago Wilderness region as a research station. This would help students to identify appropriate sites and experts, as well as to receive permits.
- ✔ Compile a thorough literature review of previous studies regarding management of natural communities and conservation of biodiversity relevant to efforts in the Chicago Wilderness region.